Chemotherapy and Treatment Scheduling: The Johns Hopkins Oncology Center Outpatient Department

Farideh Majidi, M.S., John P. Enterline, M.S., Barbara Ashley, R.N., M.S.N.
Mary E. Fowler, R.N., M.S., Lisa Lattal Ogorzalek, J.D., Raymond Gaudette
Gloria J. Stuart, Monica Fulton, R.N., M.B.A., David S. Ettinger, M.D.

The Johns Hopkins Oncology Center, Baltimore, Maryland 21287

The Chemotherapy and Treatment Scheduling System provides integrated appointment and facility scheduling for very complex procedures. It is fully integrated with other scheduling systems at The Johns Hopkins Oncology Center and is supported by the Oncology Clinical Information System (OCIS).[1] It provides a combined visual and textual environment for the scheduling of events that have multiple dimensions and dependencies on other scheduled events. It is also fully integrated with other clinical decision support and ancillary systems within OCIS.[2]

The system has resulted in better patient flow through the ambulatory care areas of the Center. Implementing the system required changes in behavior among physicians, staff, and patients. This system provides a working example of building a sophisticated rule-based scheduling system using a relatively simple paradigm. It also is an example of what can be achieved when there is total integration between the operational and clinical components of patient care automation.

INTRODUCTION

Over the past several years, there has been a notable increase in the proportion of treatments and procedures being performed on an outpatient basis at the Johns Hopkins Oncology Center. This rise in ambulatory care volumes is a result of both modern treatment trends and cost-containment efforts from third-party payers. As this trend is expected to continue, it is increasingly important to optimize the use of ambulatory care resources whenever possible.

The Johns Hopkins Oncology Center's outpatient treatment facility supports over 200 patient treatment visits per week. There are a total of 6 chairs and 14 beds which provide treatment services. Three of the treatment beds are located in private rooms for isolated procedures. The chairs and remaining beds are located in two larger contiguous areas. There are five to seven nurses which work at the facility. There are daily operational limits on a variety of treatments.

Prior to the implementation of this system, the OPD chemotherapy and treatment facility was largely scheduled on a "first-come, first-serve" basis. At best, scheduling was performed on a day-specific rather than a time-specific basis. As a result, there were significant "ebbs and flows" in patient waiting times for treatment. It was estimated that, in the majority of cases, patient waiting times were double that which should have been expected.

This unstructured scheduling method resulted in the poor utilization of OPD personnel, inefficient use of very limited facilities, and backups in pharmacy orders during peak periods. This caused long patient waits for therapy, and a potentially a poor impression of the treatment process by the patient. In many instances, nursing personnel were required to stay beyond normal working hours to complete the treatment of waiting patients. However, there were also periods during the day when there were no patients to treat.

SYSTEM REQUIREMENTS

The problem of developing an automated solution for chemotherapy treatment scheduling was multidimensional, with most of the dimensions containing large and poorly defined variations. One dimension was simply getting the patient to the facility on time so that treatment could be completed on time. This requires coordination with other activities scheduled prior to and after treatment. Another dimension dealt with those factors required to finish a patient's treatment on time to make the facility available for the next patient, e.g., timeliness of laboratory results and pharmacy orders. Still another dimension was to assure that there is adequate nursing coverage for start-up and treatment procedures. The only fixed dimension in the problem

0195-4210/92/$5.00

was the number of beds, chairs, and nurses available for patient treatment on a given day.

It is important when automating difficult logistical functions to understand the full problem, and not impose constraints which will make automation a hinderance rather than a help. In some instances problems have no good automation solutions, or the solutions create more problems than they solve. Over-structuring the required scheduling system would have reduced the flexibility required in a constantly varying environment. When provided with organized information and visual cues, the human mind can be a more powerful tool than a computer in dealing with "fuzzy logic" problems.

The envisioned system had to help provide an environment which maximizes the use of Oncology personnel and physical resources. It also had to be structured to minimize the patient cuing problems. Logical links were necessary with other Oncology Clinical Information System (OCIS) functions, such as staff and patient appointment scheduling, medication ordering and delivery, laboratory test scheduling, results, Radiation Oncology appointments, other auxiliary appointments, and general clinical information flow.

Specifically, tne facility scheduling system had to assist in scheduling a patient for treatment at a time which was compatible and appropriately sequenced with other scheduled appointments. It needed to ensure that the treatment facility and necessary personnel were scheduled for a sufficient time to complete the treatment. Sufficient time for medications to be formulated and delivered had to be built into the scheduling structure. It also had to provide adequate tools to allow for the selection of the "best fit" treatment time for the patient, facility, and nurse.

Due to the dynamic nature of oncology treatments, it had to provide capabilities for rescheduling patients, facilities, and personnel as situations change during the normal work day. Rescheduling functions had to include block schedule moves and cancellations due to frequent treatment delays and modifications. Personnel and facility overbooking capabilities were also essential, but tools were needed to monitor and assess the degree of overbooking.

Additionally, the system had to be structured to integrate with other OCIS applications, have long-term maintainability, and be modular enough to allow for expansion and enhancement with minimal difficulty. This type of systems' environment has been a primary focus in the development of all sub-systems of OCIS.[3] While not part of this project, the system was designed to allow for integration with a planned Center-wide patient tracking system across multiple appointments in a single day. The system had to assist personnel in understanding the status of the patient with regard to arrival and completion of other scheduled events on the scheduled day in "real-time". Automated charge capture capabilities were also a necessary component of the system.

SYSTEM DESCRIPTION

The OPD registrars have the primary responsibility for scheduling treatment appointments. The chemotherapy treatment scheduling system is a logical extension of the other appointment scheduling systems. The registrars have a series of "on-line" tools to assist in selecting an optimal time and facility for a specific chemotherapy treatment. As mentioned, chemotherapy and treatment scheduling is one of a variety of scheduling functions provided through OCIS. The most effective means to describe the system's "paradigm" is to understand the day-to-day interaction which the users have with the underlying system functions and data.

The scheduling of patients and real-time queries of data are performed on-line through terminals. Hard copy reports are provided as required to supplement information available on-line. Developing an effective terminal-based user interface was the most difficult task due to the complex and interdependent nature of these types of treatments.

Occupancy/Assignment Screen

As mentioned, the registrar and other appropriate personnel have access to a variety of tools to assist them in selecting the most appropriate time for a

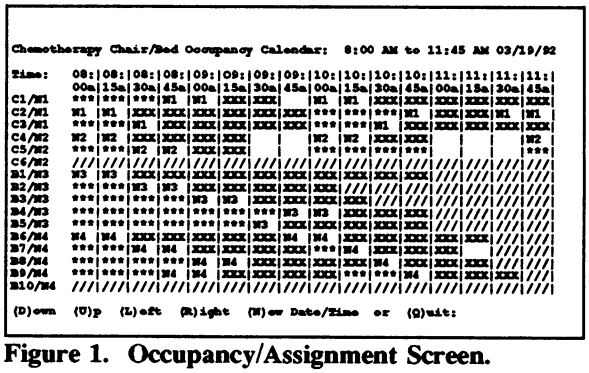

Figure 1. Occupancy/Assignment Screen.

particular patient's treatment. One of the terminal screens to assist in this scheduling process is presented in Figure 1 (Occupancy/Assignment). This screen represents the basic system paradigm. Note that this screen presents data on both the nurses' schedule and the chair/beds schedule for a four-hour time frame. Time is presented across the horizontal axis at the top of the screen in 15-minute intervals. Facility and nurse assignments are presented along the vertical axis on the left-hand side of the screen. The occupancy/assignment data necessary for scheduling are located in the rectangular array, between the time axis and the facility/personnel assignment. Thus, 15-minute blocks of time for a particular facility/nurse can be viewed in a bingo-board manner. Registrars can move forward and backward in time by selecting the (L)eft and (R)ight options. They can also view additional facilities by choosing the (D)own and (U)p options.

Chairs are designated by a "C", beds by a "B", and nurses by an "N". Blank spaces indicate that a time is available for both the nurse and the facility. The "/" symbol is used to indicate time blocking for lunch, meetings, and other necessary events. The "*" symbol indicates that time should not be scheduled for the start-up portion of a treatment. Note that Chair 6 and Bed 10 have been blocked out for the morning to allow for walk-in and stat treatments.

At a single glance, the registrar can identify both the status of the nurse and the facilities covered by the nurse for up to four nurses for a four-hour time frame. As there are potentially more than four nurses on a given day, moving to a second screen will provide data on the remaining nurses/facilities. The registrar has the option to view chairs only, beds only, or a combination of chairs and beds. The screen design will allow all beds or all chairs to be viewed on a single screen for a four-hour time block. In general, treatments require either a bed or a chair so viewing open times is relatively simple.

The philosophy behind this design is to make it easy for registrars to visually schedule patient treatments across nurses and facilities. If there are sufficient open (blank) time blocks to schedule a treatment, that is the first choice for appointments. The system also provides for overbooking.

Scheduling Overview

In this section, a few of the possible on-line terminal screens are presented. Also, a sample of the process which a registrar follows to schedule a patient is described. A sample scheduling grid is presented in Figure 1. This screen shows precisely what patient is occupying a particular facility during each time block in a given day. In order to schedule this grid, the registrars generally enter the system through the main OCIS scheduling menu shown in Figure 2. It should be pointed out that, through this menu, they can schedule, reschedule, and cancel a variety of appointments within the OPD. In general, registrars will schedule the primary physician appointment first

```
     FUNCTION                              ENTER

SCHEDULE APPOINTMENT
   PRIMARY                                  P
   AUXILIARY                                A
   CHEMO                                    C
   TREATMENT MACHINE                        T
   SIMULATION MACHINE                       S
   PRIMARY NURSE                            PN

RESCHEDULE APPOINTMENT
   PRIMARY & AUXILIARY                      RA
   PRIMARY ONLY                             RP
   AUXILIARY ONLY                           RX
   CHEMO                                    RC
   TREATMENT MACHINE                        RT
   SIMULATION MACHINE                       RS

CANCEL APPOINTMENT                          CA

ENTER: C [return]
```

Figure 2. Main OCIS Scheduling Menu

using the "P" option. During this option, the registrars are able to schedule the various tests which a physician has ordered that need to take place before the exam, e.g., blood work. The scheduled time for the physician's appointment will be automatically delayed for a long enough period to allow test results to be available for the exam. Auxiliary appointments are generally external to the Oncology Center and include radiology, and lab work, and consultation appointments. These are usually fit between the primary appointment and the chemotherapy/procedure appointment. Rescheduling and cancellation capabilities are also provided and include the capabilities of moving and canceling related appointments across time. Scheduling for Radiation Oncology treatment facilities and primary nurse appointments are also available.

This example will focus on the scheduling of the chemotherapy treatment facilities using the "C" function. Prior to using this function, the registrar will have already scheduled all tests, primary and auxiliary appointments other than Radiation Oncology.

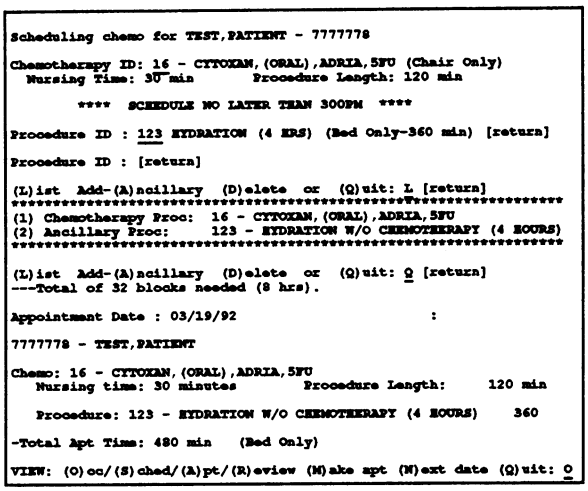

Figure 3. Sample Screen Interaction with Treatment Scheduling System.

While scheduling these earlier appointments, the registrar has the ability to view the total length of time needed for chemotherapy treatment, and available appointment times through the scheduling grid. This helps in making the earlier appointments at times which will logically lead into the chemotherapy treatment, allowing sufficient time for pharmacy interactions. All of these activities are automated or have on-line suggestions for the registrar. In the menu presented in Figure 2, the registrar is already at the patient level. When the "C" option is selected from this menu, the registrar goes through the interactive scenario presented in Figure 3.

The first part of this scenario is designed to ensure that the registrar is scheduling the correct patient (TEST, PATIENT - 7777778). In general, chemotherapy regimens are ordered by physicians using an internal code ranging from 001 to 998. Each of these codes is assigned a particular therapy combination. Presently, there are about 125 combinations used in Oncology. Listings of these codes are posted in strategic areas in the OPD, and available on-line. This reduces confusion over what therapy the physician has ordered. In this example, Chemotherapy ID number 16 has been selected. This is a combination therapy of cytoxan, adriamycin, and 5-fluorouracil. The system indicates that this is a chair-only procedure, meaning that a bed is not necessary. It indicates that the initial nursing set-up time for administering this treatment is 30 minutes and that the total procedure length (including nursing set-up) is 120 minutes. The system also indicates that this treatment is not to be scheduled later than 3:00PM.

The registrar is then given the option to add other procedures to the chemotherapy appointment. In this instance, Procedure ID 123 is selected which is hydration. This procedure takes 360 minutes and is to be performed only in a bed. Thus, the registrar knows that a bed must be used for both the chemotherapy and the procedure. The facility used during a visit always defaults to the highest level, i.e., chair, bed, and then bed in an isolated room. The registrar has the option of adding as many procedures as needed for the visit. When the registrar has finished scheduling procedures, options are given to (L)ist the selected therapies, (D)elete a therapy, or (Q)uit the scheduling function. In this example, the "List" function is selected and the scheduled treatments are provided along with necessary information. The "Quit" option is selected and the system indicates that a total of 32 x 15 minute blocks, or eight hours of therapy is needed. The date of the treatment to be scheduled and the patient's name are then presented, along with each of the treatments to be scheduled. Additional information is presented on the total length of the appointment and that it should be scheduled in a "Bed Only".

RESULTS

The scheduling system took over a month to fully implement. Even after implementation, it took another several months for its benefits in improving patient flow and staff scheduling to become apparent. The initial month to implement the system was anticipated as many patients are scheduled for one month in advance. Thus, this was a phase-in of the system and did not disrupt appointments which were already scheduled.

The additional time to see benefits from the system was not anticipated and resulted from delayed behavioral changes among patients, physicians, and nurses. Even though the new scheduling system was discussed with all patients, certain patients retained their old practices of showing up for therapy when it was convenient for them, regardless of the scheduled appointment. Thus, patients would generally arrive for their appointment well in advance of their scheduled time anticipating that they could be "fit in" as was the previous practice.

It has been difficult to change this pattern of behavior as the registrars and nurses have close relationships

with the patients and generally do whatever is required to accommodate their needs. Additionally, when new patients start therapy, older patients inform them of the "come when you want" arrangements. This perpetuates the behavior. It has been increasingly necessary to enforce start times for therapy regardless of when the patient arrives.

Once the system became relatively stable in terms of patient and staff compliance, other problems in patient flow through their oncology ambulatory care visit were identified. It was found that there were problems both in obtaining the laboratory data in a timely manner and in having the chemotherapy drugs available from the pharmacy in time for the scheduled visit. Once these were identified as problem areas, it was relatively simple to deal with them.

The system has resulted in both better load balancing in patient appointments over the day, and fewer requirements to keep the facility open after hours to treat patients. Patient waiting times have been reduced significantly. It has also helped in defining other patient and operational flow problems in the outpatient area. Presently, the system has been on-line for over 1.5 years and there is a second phase of development taking place to enhance charge-capture functions.

One interesting note is that when patients arrive, they expect to be treated in an extremely timely manner in the area assigned to them. If there is someone occupying their assigned bed or chair, they become upset and want to know what that person is doing in their space. Additionally, there is pressure by the patients to assign them to specific facilities with better views of the TV or with ports available for personal computers. These relatively minor accommodations are being addressed in this second phase of development.

CONCLUSIONS

During the initial requirements and design phases, there was continual movement toward developing a very structured, rule-based scheduling system. However, due to the great variability and confounding factors that make rules hard to define in this environment, the scheduling paradigm was constantly pushed back to a decision-support versus an expert-system model. This has proven to be an effective design that provides the structure necessary to meet the system's scheduling requirements, while not constraining creative decision making.

While the design and implementation of this scheduling system required a significant amount of effort from both the information system's staff and the users, it has been successful in improving patient-flow and reducing waiting times. The model used places the "juggling" of nurse-patient-facility availability on the registrar. It provides the tools needed to make reasonable scheduling decisions and balance the work load across nurses and facilities. Also, these tools help the registrar to fit the chemotherapy schedule into other activities the patient will have scheduled during a particular day.

One envisioned enhancement is to provide a patient tracking system which is linked with other appointment scheduling systems in OCIS. A newly implemented Radiation Oncology scheduling system has already incorporated this tracking system. It has been extremely successful in providing the monitoring functions necessary to react to patient flow problems in real time. When the tracking system is implemented Center-wide, it will indicate to all users of OCIS appointment systems (1) that the patient scheduled for a facility has arrived in Oncology, (2) where in the series of appointments scheduled for a specific day the patient was last seen, (3) where the patient is probably scheduled next, (4) any appointment backup problems being experienced in other facilities in Oncology, and (5) when the patient has arrived at a facility for treatment. Such a tracking system will be used to adjust the patient loads of individual facilities in real time as the workday progresses.

REFERENCES

1. A Clinical System for Oncology. Enterline, J.P., Lenhard, R.E., Blum, B.I., Eds., Springer-Verlag, New York, N.Y., 1989.

2. Enterline, J.P., Lenhard, R.E., Blum, B.I. The Oncology Clinical Information System. A Clinical System for Oncology. Enterline, J.P., Lenhard, R.E., Blum, B.I., Eds., Springer-Verlag, New York, N.Y., 1989. pp. 1-21.

3. Blum, B.I. The Oncology Clinical Information System. Development History. A Clinical System for Oncology. Enterline, J.P., Lenhard, R.E., Blum, B.I., Eds., Springer-Verlag, New York, N.Y., 1989. pp. 39-72.